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Systematic Studies on the Pompilidae Occurring in Japan: Genus *Irenangelus* Schulz (Hymenoptera: Pompilidae: Ceropalinae)

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Abstract.—The Japanese species of the genus *Irenangelus* Schulz (Pompilidae: Ceropalinae) are revised. Three new species are described: ***I. hikosanus* Wahis**, ***I. nambui* Shimizu**, and ***I. punctipleuris* Wahis**. *Irenangelus hikosanus* occurs in Japan (Honshu, Shikoku, Kyushu), Korea, Taiwan, and China; *I. nambui* occurs in Japan (Honshu) and Korea; *I. punctipleuris* is broadly distributed from Japan through the Philippines and Malaysia to India and Sri Lanka.

Irenangelus Schulz 1906, like *Ceropales* Latreille 1796, is one of the most aberrant genera of the family Pompilidae. All members of both genera have an uncoiled antenna, reniform eyes with the inner orbits strongly emarginate and diverging above, a fully exserted labrum in both sexes, and a strongly compressed metasomal sternum VI produced beyond tergum VI in the female.

Evans (1969, 1987) reviewed the Neotropical species of *Irenangelus*. In these papers he treated ten species, seven of which were new, and regarded *Xanthampulex* Schulz 1906 as a synonym of *Irenangelus*. Kimsey and Wasbauer (2004) revised the New World species of *Irenangelus*, adding two new species. As regards the Old World species of *Irenangelus*, Cameron (1891, 1896), Bingham (1896), Schulz (1906), Turner (1910), Rohwer (1919), Banks (1934), and Wahis (1988) described either single species or, at most, a few new species, but no comprehensive revisionary studies have been published.

Species of *Irenangelus* have long been recognized as cleptoparasites of other pompilids, as are species of *Ceropales*. Thus, Williams (1919) reared an *Irenangelus* wasp from a nest of *Auplopus nyemitawa* (Rohwer 1919) and several wasps in this genus from cocoons of nests of *Tachypompilus analis* (Fabricius 1781) in the Philippines. At least one wasp reared belonged to *I. luzonensis* (Rohwer 1919). In Costa Rica, Wcislo *et al.* (1988) observed females of *I. eberhardi* Evans 1987 fly or perch near nests of *Auplopus semialatus* Dreisbach 1963, enter an open cell containing a spider, and extend her gaster deep into the cell. They reared several wasps of this parasite from one of the nests of *A. semialatus*. Shimizu (see below) found females of a Japanese species of *Irenangelus* attempting to oviposit eggs into a slit of the booklung of heteropodid spiders that the host pompilids had captured and then transported.

Irenangelus is mainly distributed in the Oriental and Neotropical regions. In Japan only one species of the genus has been known since Yasumatsu (1933) recorded the species from Honshu, Kyushu, and Taiwan as *Xanthampulex pernix* (Bingham 1896). This species is distributed also in Korea and China, and differs from *X. pernix*, which was originally recorded from

"Tenasserim" (Burma). Recently specimens of a further two species of this genus were collected from Honshu, Japan. One of them is found in Korea in addition to Japan, and the other occurs from Japan through Southeast Asia to South Asia. It was found that these three species are undescribed.

In this paper, we review the generic characters and phylogenetic relationships of *Irenangelus*, describe three new species and provide a key to their identification.

MATERIALS AND METHODS

The terminology of the wing veins and cells follows Day (1988). The following morphological terms and abbreviations are used: antennocular line, the anterior margin of the frons in dorsal view; scutal groove, a pair of longitudinal grooves between the notaulus and parapsidal sulcus on the mesoscutum (Evans (1969) and Kimsey and Wasbauer (2004) called this the "notaulus"); LID, the lower interocular distance; MID, the middle interocular distance; OOL, the ocello-ocular line; POL, the postocellar line; SMC, the submarginal cell of the fore wing; UID, the upper interocular distance.

Measurements were made in the following ways: clypeus length versus breadth, being measured comparing the length of the clypeus from the uppermost point of the front-clypeal sulcus to the apical margin to the maximum breadth of the clypeus; labrum length versus breadth, being measured comparing the longest part of the labrum to the breadth across the base of the labrum; breadth of flagellomere I, being measured across the maximum breadth of flagellomere I in dorsal view. In the description of each species, the measurements of the holotype are given in parentheses.

Specimen depositories are abbreviated as follows: ZMUC, Zoological Museum, University of Copenhagen, Copenhagen, Denmark; UCDC, R. M. Bohart Museum of Entomology, University of California, Davis, California, USA; ELKU, Collection of Entomological Laboratory, Kyushu University, Fukuoka, Japan; AEIC, American Entomological Institute, Gainesville, Florida, USA; FSAG, Entomologie fonctionnelle et évolutive, Faculté universitaire des Sciences agronomiques, Gembloux, Belgique; RMNH, Nationaal Naturhistorische Museum, Leiden, Netherlands; BMNH, Natural History Museum, London, UK; OMNH, Osaka Museum of Natural History, Osaka, Japan; CNC, Canadian National Collection of Insects, Ottawa, Ontario, Canada; NSMT, Department of Zoology, National Science Museum, Tokyo, Japan; TMUB, Laboratory of Zoological Systematics, Department of Biological Sciences, Tokyo Metropolitan University, Tokyo, Japan; USNM, National Museum of Natural History, Washington, D. C., USA.

SYSTEMATICS

Genus *Irenangelus* Schulz

Irenangelus Schulz 1906: 175. Type of genus: *Irenangelus hornus* Schulz 1906: 160, by monotypy.

Xanthampulex Schulz 1906: 183. Type of genus: *Xanthampulex trifur* Schulz 1906: 183, by monotypy.

Description.—Further to the descriptions of this genus by Evans (1969) and Kimsey and Wasbauer (2004) we note the following characteristics: gena flattened or concave just posterior to outer orbit at least below; posterolateral margin of pronotum almost straight (Figs 2F, 3D); scutal groove deeply impressed in many species (Figs 1A, 2C); metapostnotum well developed at least medially (Figs 1A, D, 2A, F, 3D); fore wing vein M reaching outer wing margin (Figs 2A, 5A, B); metatibia with longitudinal sharp groove along upper margin of brush on inner side (Fig. 2A); apicoventral seta on metatarsomere V long and setiform (see Shimizu *et al.* 1998: fig. 3); female laterosterna of metasomal sternum VI extending dorsad, scarcely overlapping to envelope sting apparatus; sting almost

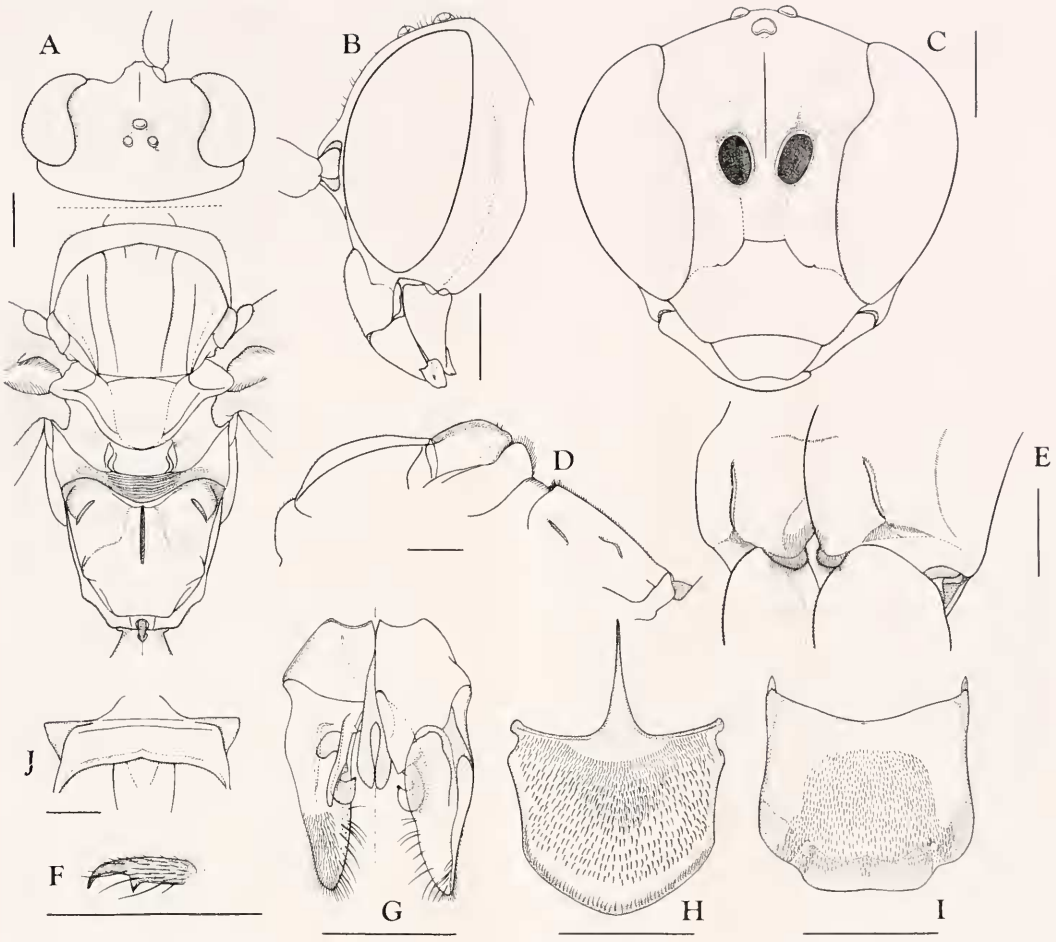

Fig. 1. *Irenangelus hikosanus* n. sp. (A–F, holotype female; G–I, paratype male from Japan) and female *I. pernix* Bingham from Bali, Indonesia (J). A, Head and mesosoma, dorsal view; B, head, lateral view; C, head, frontal view; D, mesosoma, lateral view; E, mesosternum and mesocoxa, ventrolateral view; F, right metatarsal claw, outer view; G, genitalia (left half, ventral view; right half, dorsal view); H, subgenital plate, ventral view; I, sternum VI, ventral view. Scale lines: 0.5 mm.

straight; male sternum VI without a pair of sublateral hook-like projections posteriorly (Fig. 1I); digitus volsellaris with large semicircular emargination on inner margin (Figs 1G, 2I, 3L).

Diagnosis.—*Irenangelus* is closely related to *Ceropales*, forming a monophyletic group, the subfamily Ceropalinae (Shimizu 1994, Pitts et al. 2006). These two genera are distinguishable on the characteristics shown in Table 1.

Phylogenetic relationships.—On the basis of morphological characteristics, both Shimizu (1994) and Pitts et al. (2006) treated the Ceropalinae (*Ceropales* + *Irenangelus*) as the most basal clade in the Pompilidae. This subfamily is thus considered to be the sister group to the rest of the family. Based on this hypothesis, there is a biological inconsistency: although the Ceropalinae are placed as the earliest offshoot of the pompilid stock, all species of the subfamily whose behaviour is known are cleptoparasitic. To avoid this contradiction, Shimizu (1994) considered that the behavioural type of the Ceropalinae has evolved directly from that of the parasitoids, which is the most likely life history of a common ancestor of the

Table 1. Comparison of differential characters between *Irenangelus* and *Ceropales* in the broad sense, including *Priesnerius* and *Hemiceropales*.

Irenangelus	*Ceropales*
1. Metacoxa normal-sized, less than 1.5× as long as mesocoxa.	Metacoxa much larger than mesocoxa, more than 1.5× as long as mesocoxa.
2. Ventral angle of pronotum short and blunt, not attaining dorsal margin of procoxa (Fig. 3D).	Ventral angle of pronotum long and acute, partly covering dorsal margin of procoxa.
3. Posterolateral margin of pronotum almost straight (Figs 2F, 3D).	Posterolateral margin of pronotum strongly curved inward.
4. Inner margin of male protarsomere V not produced.	Inner margin of male protarsomere V produced ventrally.
5*. Male subgenital plate flat or gently convex (Figs 1H, 2H, 3L).	Male subgenital plate tectate with median carina.

*Character treated by Kimsey and Wasbauer (2004).

Pompilidae. Similarly, Day (1988: 16) stated: "it seems more probable that *Ceropales* has evolved from an ancestral group already specialized as ectoparasitioids." This presumption seems likely given that the two important characteristics of Ceropalinae females are shared with other pompilids known to behave as parasitoids, viz- (i) the strongly exposed clypeus, and (ii) the laterally compressed sternum VI.

Biology.—One or more Philippine species of *Irenangelus* are known to be cleptoparasites of *Auplopus uyemitawa* (Pepsinae) and *Tachypompilus analis* (Pompilinae), and *I. eberhardi* a cleptoparasite of *Auplopus semialatus* (Pepsinae) (Williams 1919). Shimizu observed the cleptoparasitic behaviour of *I. hikosanus* Wahis n. sp., which pursues its host pompilid *Platydialepis ryoheii* (Ishikawa 1956) (Pepsinae) as the latter transports her prey, *Heteropoda forcipata* (Karsch 1881) (Heteropodidae) to her nest. Eventually the parasite pounces on the spider and extends her gaster, attempting to insert its tip into a slit of the spider's booklung. The details of this behaviour will be treated in a separate paper.

Distribution.—This genus is known from Oriental, Neotropical, Australian, East Asian, and Madagascan Regions (see Wahis 1988), but is best represented in the first two regions.

KEY TO FEMALES AND MALES OF *IRENANGELUS* OCCURRING IN JAPAN

1. Flagellum crenulate in profile, *i.e.*, flagellomeres II–X each with angular swelling below (Fig. 3A); all tarsal claws bifid, inner ray truncate (Fig. 3G); propodeum transversely striate; metasomal tergum I gradually narrowed and petiolate (tergum I narrower immediately behind articulation with propodeum than width at articulation itself) (Fig. 3E) or parallel-sided basally; head and mesosoma with irregularly-distributed punctures (Figs 4C–F). (Head and mesosoma black, variegated with bright yellow markings; metasoma and legs predominantly reddish brown; body length 8–12 mm) . . . . . ***I. punctipleuris* Wahis, n. sp.**

– Flagellum not crenulate in profile; all tarsal claws dentate (Fig. 1F) or sub-bifid (Fig. 2G), inner ray acute; propodeum smooth, never striate; metasomal tergum I abruptly narrowed, not petiolate or parallel-sided basally (Fig. 2A); head and mesosoma impunctate (Fig. 4B) 2

2. Propodeum with lateral tubercle between spiracle and posterior rim (Fig. 1A); interantennal area distinctly raised (Figs 1B, 4B); fore wing crossvein cu-a originating at or slightly distal to separation of vein M+Cu (Fig. 5A); fore wing

SMC3 removed by approximately its own length from outer wing margin; apical margin of subgenital plate strongly convex (Fig. 1H); body predominantly yellowish brown; body length 8–15 mm ..... ***I. hikosanus* Wahis, n. sp.**

– Propodeum without lateral tubercle between spiracle and posterior rim (Fig. 2A); interantennal area not raised, continuous to upper frons (Fig. 2D); fore wing crossvein cu-a originating slightly basad of separation of vein M+Cu (Fig. 2A); fore wing SMC3 removed by much more than its own length from outer wing margin; apical margin of subgenital plate slightly emarginate or almost truncate (Fig. 2H); body predominantly blackish brown to black; body length 5–9 mm .... ***I. nambui* Shimizu, n. sp.**

Irenangelus hikosanus Wahis, new species
(Figs 1A–I, 4B, 5A)

Xanthampulex pernix: Yasumatsu 1933: 143, figure 1, ♂♀, misidentification; Kim 1970: 807.
Irenangelus pernix: Lelej et al. 1994: 145; Lelej et al. 1995: 46; Shimizu 1994: 45; Shimizu 1996: 507; Shimizu et al. 1998: 429, figure 3.

Female.—Length: Body 9.1–14.5 (9.8) mm; fore wing 8.7–11.3 (8.7) mm. *Coloration*: Body and appendages predominantly yellowish brown and polished. Following light yellow: mandible (apical portion dark brown), clypeus (lateral side sometimes yellowish brown), frons along inner orbit, gena along outer orbit, ventral margin of scape, maxillary and labial palpi, pronotum posteriorly and laterally, discs of scutellum and metanotum, posterior rim of propodeum, procoxa, and sometimes interantennal tubercle ventrally, labrum, and episternum posteriorly. Apical 4 or 5 flagellomeres black dorsally. Basilateral and posterior portions of metasomal tergum I and posterior portions of following terga more or less darkened. Metatarsus becoming darker towards apex. Wings hyaline with yellowish brown tint, iridescent in certain lights, narrowly and weakly infuscate along outer margins. Pterostigma dark brown. *Punctation*: Body devoid of punctures. *Pubescence and setae*: Pubescence on body usually very short and decumbent; metanotum, lateral portion of metapostnotum, and propodeum with long, sub-erect, brown pubescence. Vertex, labrum, mandible, propleuron, and sterna V-VI with short yellowish brown to brown setae; remainder of body and legs almost devoid of setae. *Head*: 1.1–1.2 (1.1)× as broad as long. Vertex moderately to strongly convex between eye tops (Fig. 1C). Frons distinctly tuberculate between antennal sockets (Figs 1B, 4B); upper frons broadly depressed along median line, the latter being sharply impressed on antennal tubercle but becoming obscure near anterior ocellus. Antennocular line depressed beside antennal tubercle (Fig. 1A). Inner orbits distinctly emarginate at upper 1/3, gently convergent below (Fig. 1C). UID:MID:LID=9.1–9.4:10:6.3–6.7 (9.4:10:6.3). MID 0.57–0.60 (0.58)× head width. Ocelli forming acute triangle, this area being distinctly raised. POL:OOL= 1:2.5–3.1 (3.1). Clypeus slightly convex, 1.8–2.0 (2.0)× as broad as long; anterior margin truncate, weakly and arcuately emarginate (Fig. 1C); lateral sides strongly convergent towards apex. Labrum 1.8–2.1 (2.1)× as broad as long; anterior margin feebly and triangularly emarginate. Mandible narrowly rounded without sharp carina laterally. Malar space short (Fig. 1B). Genae 0.4–0.5 (0.5)× eye width in profile, roundly receding in dorsal view. Scape with carina long but not sharp beneath; face slightly concave laterally in dorsal view. Flagellomere I 2.1–2.9 (2.5)× as long as wide and 0.34–0.48 (0.44)× as long as UID; flagellomeres I and II in ratio of 10:9.3–11 (10:10). *Mesosoma*: Pronotum

short (Fig. 1A); anterior margin of disc arcuately convex in dorsal view, its anterolateral corner rounded; lower anterolateral tubercle not much swollen, being almost concealed by disc in dorsal view (compare Fig. 1A with Fig. 1J: *I. pernix*); posterior margin arcuate with small median notch. Mesoscutum with scutal groove sharply impressed anteriorly, becoming shallower and broader posteriorly, but almost attaining scuto-scutellar sulcus; parapsidal sulcus appearing as a fine, raised line; posterolateral margin broadly reflexed. Discs of scutellum and metanotum remarkably projecting, the latter steeply falling posteriorly (Fig. 1D). Posteromedian lobes of mesosternum well developed and digitate, apices close to each other (Fig. 1E). Metapostnotum 0.7–1 (0.7)× as long as metanotum at midline, deeply sunken between metanotum and propodeum (Fig. 1D), with fine, transverse striae. Propodeum strongly depressed along anterior margin, almost linearly sloping in profile, with one or two lateral tubercles between spiracle and posterior rim (Fig. 1A); infrastigmal tubercle roundly raised; median groove impressed only anteriorly; surface smooth, not striate. *Metasoma*: Slender and almost parallel-sided medially. Tergum I abruptly narrowed, not petiolate or parallel-sided basally. *Legs*: Longer spur of metatibia 0.69–0.77 (0.73)× as long as metatarsomere I. Tarsal claws with vertical tooth near middle (Fig. 1F). *Wings*: Fore and hind wing venation as shown in Fig. 5A. Fore wing crossvein 2r-rs originating beyond middle of pterostigma. Crossvein cu-a originating at or slightly distal to point of separation of vein M+CuA. SMC2 trapezoid, receiving crossvein 1m-cu at basal 0.54–0.70 (0.58). SMC3 narrowed on vein Rs by 0.70–0.82 (0.77)× its length on vein M, 1.1–1.4 (1.3)× as long as SMC2 on vein M, 1.2–1.5 (1.4)× as long as SMC2 on vein Rs, receiving crossvein 2m-cu at basal 0.55–0.61 (0.55). Hind wing crossvein rs-m straight, oblique to vein M. Crossvein cu-a at angle of approximately 150° to vein A.

Male.—Very similar to female. *Length*: Body 7.1–12.4 mm; fore wing 7.1–11.4 mm. *Head*: 1.1–1.2× as broad as long. UID:MID:LID=9.0–9.3:10:6.5–6.8. MID 0.57–0.62× head width. POL:OOL=1:2.3–2.6. Clypeus 1.8–2.0× as broad as long. Labrum 1.8–1.9× as broad as long. Gena 0.4–0.5× eye width in profile. Flagellomere I 2.0–2.5× as long as wide, 0.34–0.43× as long as UID; flagellomeres I and II in ratio of 10:9.2–11. *Mesosoma*: Metapostnotum 0.8–1× length of metanotum at midline. *Legs*: Longer spur of metatibia 0.69–0.76× length of metatarsomere I. *Wings*: Fore wing SMC2 receiving crossvein 1m-cu at basal 0.56–0.70. SMC3 narrowed on vein Rs by 0.67–0.79× its length on vein M, 1.1–1.4× length of SMC2 on vein M, 1.1–1.4× as long as SMC2 on vein Rs, receiving crossvein 2m-cu at basal 0.55–0.67. *Subgenital plate* (Fig. 1H): Lateral sides gently convergent towards apex; apical margin sub-triangularly convex; ventral surface covered with minute setae except for subapical portion. *Genitalia* (Fig. 1G): Paramere with strong setae apicomedially; parapenial lobe slightly extending beyond apex of aedeagus.

Distribution.—Japan (Honshu, Shikoku, and Kyushu), Korea, Taiwan (Yasumatsu 1933), and China (Fig. 6).

Type material.—Holotype ♀ (ELKU), Japan, Kyushu, Mt. Hikosan, 22.viii.1954, K. Yasumatsu. Paratypes: **Japan: Kyushu**: Mt. Hikosan, Fukuoka Pref., 5.viii.1940, K. Yasumatsu, 1♂ (ELKU). Lake Yamashita, Kokonoe-machi, Oita Pref., 9.ix.1997, R. Matsumoto, 1♀ (OMNH). Mt. Ariake-yama, Izuhara-machi, Tsushima Is., 24.vii.2001, R. Oomuta, 1♂ (TMUB). **Japan: Shikoku**: Mt. Ishizuchi-san, Omogo-mura, Ehime Pref., 17.viii.2002, M. Shiraishi, 1♀ (TMUB). Omogo, Omogo-mura, Ehime Pref., 16.viii.1951, T. Esaki, 1♂ (ELKU); 23.viii.1953, T. Edashige, 1♂ (TMUB); 23.ix.1999, A. Shimizu, 2♀ (TMUB). **Japan: Honshu**: Jomine Shrine, Yanô, Kamiizumi-mura, Saitama Pref., 3.viii.1994, T. Nambu, 1♂ (TMUB). Onouchi, Ogano-machi, Saitama Pref., 10.x.1992, T. Nambu, 1♀ (TMUB). Onagata, Yoshida, Saitama Pref., 18.viii.1988, T. Nambu, 6♀1♂ (TMUB), 1♀ (FSAG); 26.viii.1988 (2♀: TMUB, FSAG), 1, 3.viii.1994 (1♀: TMUB), 24,

26.viii.1995 (2♀: TMUB), 28.vii.2001 (2♂: TMUB), A. Shimizu. Riv. Ôchi-gawa, Ôtaki-mura, Chichibu, Saitama Pref., 6.ix.1970, T. Nambu, 2♀ (TMUB); 6.ix.1999, A. Shimizu, 1♀ (TMUB). Kawamata, Otaki, Chichibu, 18.viii.2005, A. Shimizu, 1♀ (TMUB). Mt. Komaga-take, 1050 m, Hakone, Kanagawa Pref., 8.viii.2005, A. Shimizu, 1♂ (TMUB). East of Fujikawaguchiko-machi, Minami-tsuru-gun, Yamanashi Pref., 5.viii.2006, H. Takahashi, 2♂ (TMUB). Mt. Sanage, Evergreen forest, Aichi Pref., deciduous forest, 8.ix.2002, P. Tripotin, 1♀. Jeollanamdo, Gurye-gun, Toji-myeon, Naedong-li, Piakol Valley, on wild wine flowers, 3.viii.2001, P. Tripotin, 1♀.

Etymology.—This species is named after the type locality.

Remarks.—This new species is similar to *I. pernix*, but the following characters distinguish them:

I. hikosanus	*I. pernix*
1. Lower anterolateral tubercle of pronotum slightly and roundly produced, almost concealed by disc in dorsal view (Fig. 1A).	Lower anterolateral tubercle of pronotum angulate, markedly projecting beyond disc in dorsal view (Fig. 1J).
2. Interantennal tubercle merging into upper frons, with median line finely impressed (Fig. 4B).	Interantennal tubercle abruptly raised from slightly depressed upper frons, with median line deeply and broadly impressed (Fig. 4A).

28.viii–3.ix.1992, T. Kanbe, Malaise trap, 1♀ (TMUB). Hio, Kanazawa-shi, Ishikawa Pref., 27.viii, 1998, Y.Tazaki, 1♂ (NSMT). Misaka-dani, Izumi-mura, Ono-gun, Fukui Pref., 13.ix.2002, H. Takahashi, 1♀ (TMUB). Kaizuka-shi, Izumi-katsuragisan, Osaka, 1.x.2000, R. Matsumoto, 1♀ (OMNH); 13–23.vii.2002 (1♂), 23.vii–2.viii.2002 (2♂), 2–10.viii.2002 (2♂), 20.viii–2.ix.2002 (1♀), 2–14.ix.2002 (1♀), 23.ix–2.x.2002 (1♀), 2–11.x.2002 (1♂), Malaise trap, R. Matsumoto, (OMNH). Kishiwada-shi, Izumi-katsuragisan, Osaka, 20–30.vi.2002 (1♀), 30.vi–13.vii.2002 (1♀1♂), 13–23.vii.2002 (2♀), 23.vii–2.viii.2002 (1♂), 2–10.viii.2002 (2♂), 10–20.viii.2002 (1♂), 23.ix–2.x.2002 (4♀), Malaise trap, R. Matsumoto, (OMNH). Six stage of Mt. Atago-yama, Ukyo-ku, Kyoto-shi, 27.viii.1987, A. Ichikawa, 1♀ (OMNH). Hanase Pass, Kyoto-shi, 10.ix.1999, R. Matsumoto, 1♀ (OMNH). Mimuro, Shingo-cho, Okayama Pref., 6.ix.1992, R. Matsumoto, 1♀ (OMNH). Kozagawa, Wakayama Pref., 20.ix.1957, S. Momoi, 3♀ (TMUB). Daisen, Tottori Pref. (Hôki), 19.viii.1932, S. Yasimoto, 1♂ (ELKU). **Korea**: Chungcheongnamdo, Keumsan, Poseoksa, 10.viii.1998 (1♀), 22.viii.1998 (1♀), 24.ix.2000 (1♀), ix.2001 (2♀), P. Tripotin, (FSAG). Kyeongsangnamdo, Jirisan, Hamyang-gun, Macheon-myon, Samjeong-li Jirisan, 700 m, 23–25.viii.2002 (4♀), 10–20.ix.2003 (1♂), Malaise trap, P. Tripotin, (FSAG). **CHINA**: Szechwan, Suifu, 1000–1500 m, 1–21.vi.1928, D. Graham, 1♀ (USNM).

Non-type material.—**Korea**: Chungcheongnamdo, Keumsan, Poseoksa, along trail in

Irenangelus nambui Shimizu, new species
(Fig. 2)

Female.—Length: Body 4.5–7.6 (5.5) mm; fore wing 4.7–6.9 (5.2) mm. *Coloration*: Body predominantly blackish brown to black and polished. Following ivory-white: clypeus and labrum laterally, mandible (apical portion brown), ventral margin of scape, maxillary and labial palpi, procoxa (basal portion more or less dark brown), protrochanter, and sometimes profemur, mid and hind coxae, trochanters, femora and tibiae partly. Remainder of fore leg light brown. Mid and hind legs predominantly brown, darker than fore leg, but somewhat lighter ventrally than dorsally. All tibial spurs ivory-white to yellowish light brown. Posterolateral margin of pronotum, lateral and posterior portions of metasomal terga, and posterior portions of metasomal sterna light brown to ferruginous. Wings hyaline, iridescent in certain lights, weakly infuscate along outer margins. Pterostigma dark brown. *Punctation*: Body devoid of punctures. *Pubescence and setae*: Body and legs with short, appressed white pubescence, longer and denser on lower frons, clypeus, lower pronotum, propleuron, mesopleuron, lower metapleuron, propodeum, and coxae. Upper

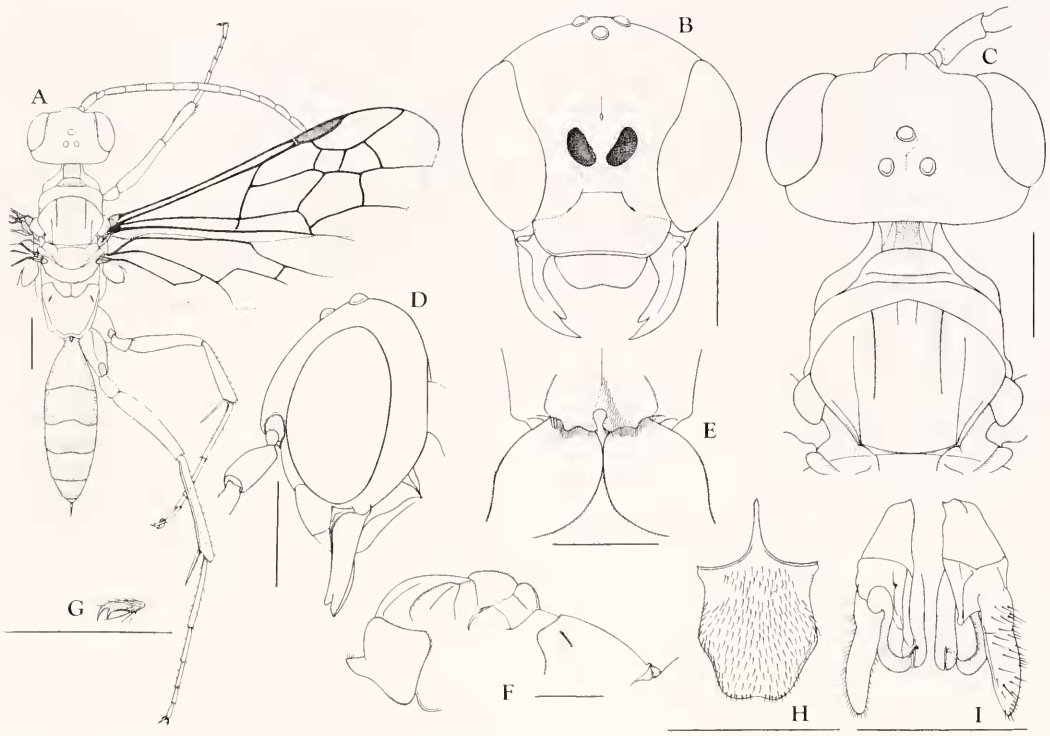

Fig. 2. *Irenangelus nambui* n. sp. (A–G, holotype female; H–I, paratype male from Japan). A, Whole body, dorsal view; B, head, frontal view; C, head, pronotum, and mesoscutum, dorsal view; D, head, lateral view. E, mesosternum and mesocoxa, ventral view; F, mesosoma, lateral view; G, right metatarsal claw, outer view; H, subgenital plate, ventral view. I, genitalia (left half, ventral view; right half, dorsal view). Scale lines: 0.5 mm.

frons, vertex, clypeus, labrum, mandible, apices of terga VI and sterna IV–V, and sternum VI with short pale setae. *Head*: 1.2× as broad as long. Vertex strongly convex in frontal view (Fig. 2B). Frons with interantennal area not tuberculate but slightly overhanging antennal sockets (Fig. 2D); median line impressed only on lower half. Antennocular line nearly transverse (Fig. 2C). Inner orbits slightly emarginate a little above middle, strongly divergent above. UID:MID:LID=9.8–10.1:10:6.8–7.1 (10:10:6.9). MID 0.57–0.60 (0.60)× head width. Ocelli forming acute triangle, this area being scarcely raised. POL:OOL=1:2.5–3.6 (1:3.6). Clypeus slightly convex, 2.1–2.4 (2.2)× as broad as long; anterior margin truncate, weakly and arcuately emarginate (Fig. 2B); lateral sides arcuately convergent towards apex. Labrum 2.5–3.0 (3.0)× as broad as long; anterior margin arcuately emarginate. Mandible carinate laterally. Malar space short. Genae 0.3–0.4 (0.4)× eye width in profile, roundly receding in dorsal view. Scape sharply carinate beneath; lateral face slightly concave in dorsal view. Flagellomere I 2.9–3.5 (3.0)× as long as wide and 0.45–0.49 (0.47)× length of UID; flagellomeres I and II in ratio of 1:0.94–1.0 (1:0.98). *Mesosoma*: Pronotum short; anterior margin of disc arcuately convex in dorsal view, its anterolateral corner gently rounded (Fig. 2C); lower anterolateral tubercle not much swollen, being completely concealed by disc in dorsal view; posterior margin arcuate with small median notch. Mesoscutum with scutal groove sharply impressed anteriorly, becoming shallower and broader posteriorly, obsolete just an-

terior to scuto-scutellar sulcus; parapsidal sulcus finely impressed; posterolateral margin narrowly reflexed. Discs of scutellum and metanotum distinctly projecting (Fig. 2F), the latter being pyramidal. Posteromedian lobes of mesosternum short but bilobed, their inner lobes close to each other (Fig. 2E). Metapostnotum 0.7–0.9 (0.7)× length of metanotum at midline, with few very fine striae anteriorly and distinct longitudinal median groove. Propodeum weakly convex in profile (Fig. 2F), scarcely depressed along anterior margin, without lateral tubercle or infrastigmal tubercle (Fig. 2A); median groove obsolete; surface smooth, not striate. *Metasoma*: Slenderly fusiform. Tergum I abruptly narrowed, not petiolate or parallel-sided basally. *Legs*: Longer spur of metatibia 0.65–0.74 (0.69)× metatarsomere I. Tarsal claws sub-bifid: inner ray sub-parallel to outer ray, acute. *Wings*: Fore and hind wing venation as shown in Fig. 2A. Fore wing crossvein 2r-rs originating before middle of pterostigma. Crossvein cu-a originating slightly basad of point of separation of vein M+CuA. SMC2 rhomboid, receiving crossvein 1m-cu at basal 0.43–0.56 (0.52). SMC3 narrowed on vein Rs by 0.42–0.53 (0.51)× its length on vein M, 1.2–1.5 (1.3)× as long as SMC2 on vein M, 0.69–1.1 (0.87)× as long as SMC2 on vein Rs, receiving crossvein 2m-cu at apical 0.54–0.66 (0.58). Hind wing crossvein rs-m almost straight, oblique to vein M. Crossvein cu-a forming angle of 135–140° to vein A.

Male.—Very similar to female. *Length*: Body 3.9–8.3 mm; fore wing 3.7–6.5 mm. *Head*: 1.2× as broad as long. UID:MID:LID=9.9–10.1:10:7.0–7.7. MID 0.57–0.60× head width. POL:OOL=1:2.1–3.1. Clypeus 2.3–2.5× as broad as long. Labrum 2.6–3.2× as broad as long. Gena 0.3–0.4× eye width in profile. Flagellomere I 2.2–2.7× as long as wide and 0.38–0.43× as long as UID; flagellomeres I and II in ratio of 1:0.96–1.1. *Mesosoma*: Metapostnotum 0.8–1× length of metanotum at midline. *Legs*: Longer spur of metatibia 0.66–0.73× metatarsomere I. *Wings*: SMC2 receiving crossvein 1m-cu at basal 0.44–0.60. SMC3 narrowed on vein Rs by 0.44–0.73× its length on vein M, 1.1–1.6× as long as SMC2 on vein M, 0.64–1.4× as long as SMC2 on vein Rs, receiving crossvein 2m-cu at apical 0.50–0.66. *Subgenital plate* (Fig. 2H): Broadened medially; apical margin slightly emarginate or truncate; ventral surface covered with minute setae. *Genitalia* (Fig. 2I): Paramere without strong setae apicomedially; parapenial lobe short, not attaining apex of aedeagus.

Distribution.—Japan and Korea (Fig. 6).

Type material.—Holotype ♀ (TMUB), Nageishi Pass, Higashi-Mikabo, Gunma Prefecture, 28.viii.1986, T. Nambu. Paratypes: **Japan: Honshu**: Showa, Mt. Hakase, 1000 m, Beech forest, Fukushima Pref., 29.vi–26.vii.1998 (1♂), 27.vii–23.viii.1998 (6♀7♂), 24.viii–19.ix.1998 (1♀2♂), Malaise trap, T. Muroi, (TMUB). Imperial Palace, Chiyoda-ku, Tokyo, 28.v.1999, T. Nambu, 1♂ (TMUB). Mt. Komaga-take, 1000–1300 m, Hakone, Kanagawa Pref., 11.vii.2000 (1♂), 30.viii.2000 (1♀), H. Nagase, (TMUB); 18.vii.2001 (1♀7♂: TMUB; 1♂, FSAG), 1.viii.2001 (2♂: TMUB), A. Shimizu. Takekurabe-yama, Maruoka-cho, Fukui Pref., 5.ix.1994, Y. Haneda, 1♀ (TMUB). Akausagi-yama, Ohno-shi, 23.ix.1974, Y. Haneda, 1♀ (FSAG). Shitara, Beech forest, 900 m, Uradani, Aichi Pref., 25–31.vii.1994 (1♂), 29.viii–4.ix.1994 (1♂), Malaise trap, K. Yamagishi, (TMUB); 29.viii–4.ix.1994, Emergence trap, K. Yamagishi, 1♀1♂ (TMUB); 19–25.ix.1994, Pan trap, K. Yamagishi, 1♀ (TMUB); 1–7.viii.1994 (1♂: TMUB), 22–28.viii.1994 (1♀1♂: TMUB; 1♀, FSAG), Malaise trap, T. Kanbe. Asahi, Yawata, 650 m, Deciduous forest, 17–26.vi.1998 (2♂), 12–21.viii.1998 (1♀1♂), 15–25.ix.1998 (1♀), Malaise trap, M. Ozawa, (TMUB). Mt. Sanage, Evergreen forest, Aichi Pref., 28.viii–3.ix.1992, Emergence trap, K. Shima, 1♀ (TMUB); 4–10.ix.1992, Malaise trap, T. Kanbe, 1♀ (TMUB); 16–22.ix.2002, Malaise trap, M. Kiyota, 1♂ (TMUB). **Korea**: Kyeongsangnamdo, Jirisan, Hamyang-gun, Macheon-myon, Samjeong-li, 700 m, 35°20′55N 127°38′21E, Malaise trap, 10–20.ix.2003, P. Tripotin, 2♀2♂ (FSAG).

Etymology.—This species is named in honor of the provider of the holotype specimen.

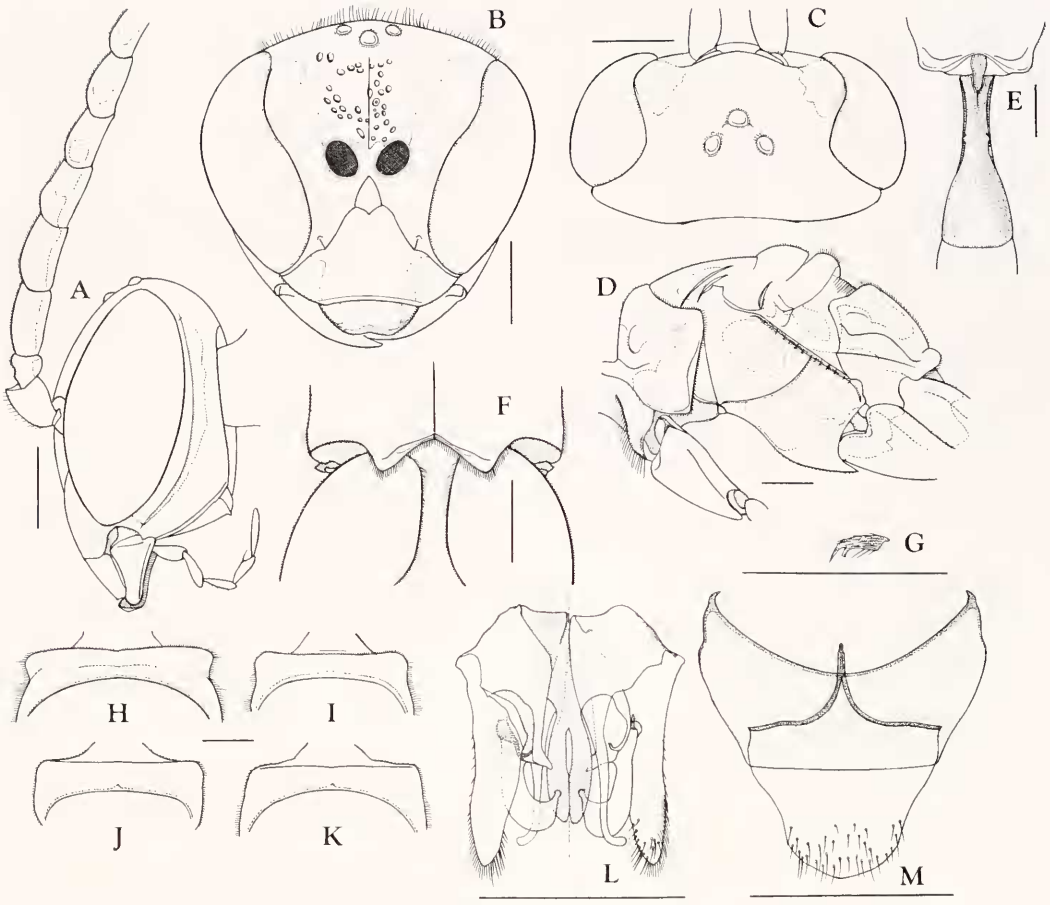

Fig. 3. *Irenangelus punctipleuris* n. sp. (A–G, I, holotype female; H, J–K, paratype females: H, from Sulawesi; J, from Brunei; K, from Japan); L–M, paratype male from Japan). A, Head and antenna, lateral view; B, head, frontal view; C, head, dorsal view; D, mesosoma, lateral view; E, metasomal tergum I, dorsal view; F, mesosternum and mesocoxa, ventral view; G, right metatarsal claw, outer view; H–K, pronotum, dorsal view; L, genitalia (left half, dorsal view; right half, ventral view); M, sternum VII and subgenital plate, ventral view. Scale lines: 0.5 mm.

Remarks.—In *Irenangelus* this species is unique in its predominantly dark brown to black body and wholly transparent wings.

Irenangelus punctipleuris Wahis, new species

(Figs 3, 4C–F, 5B–C)

Female.—Length: Body 8.1–12.4 (10.0) mm; fore wing 6.2–9.3 (7.9) mm. *Coloration*: Head, mesosoma and coxae black with following bright yellow: clypeus and labrum (lateral portions black), frons between and below antennal sockets, upper frons along inner orbit and gena along outer orbit broadly, scape and pedicel (dorsal faces dark brown to black), pronotal disc (lateral margin black), ventral and posterolateral margins of pronotum broadly, posteromedian elliptic spot and lateral streak on mesoscutum, median spot on scutellum, metanotal disc, oblong spot on upper mesopleuron, this spot being sometimes obsolete, two large spots on lower mesopleuron, these often being continuous (Figs 4E–F), median triangular and lateral longitudinal marks on propodeum, these being continuous posteriorly, oblique spot on upper metapleuron, this spot being

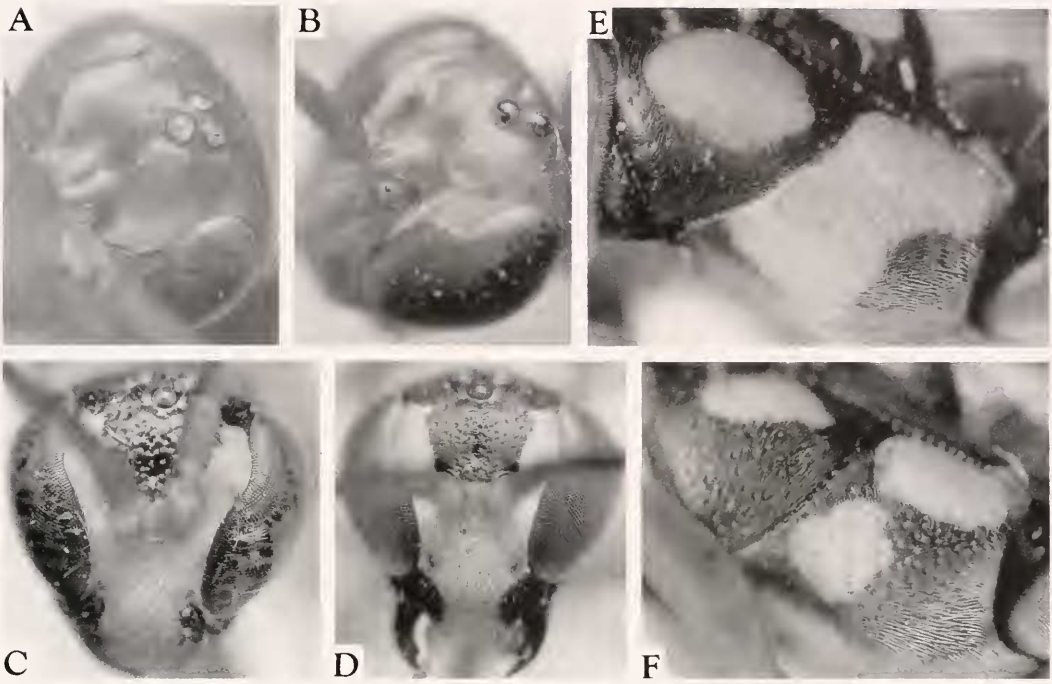

Fig. 4. Female head (A–D) and mesopleuron (E–F) of *Irenangelus* (A–B, dorsolateral view; C–D, frontal view; E–F, lateral view). A, *I. pernix* Bingham from Bali, Indonesia; B, *I. hikosanus* n. sp., holotype; C–F, *I. punctipleuris*, n. sp. (C, E, holotype; D, F, paratype from Japan).

sometimes obsolete, posterodorsal mark on lower metapleuron, this being continuous with lateral propodeal mark, apical greater parts of coxae, and sometimes side of metanotum and anterior portion of metapostnotum. Following reddish brown: flagellomeres I–IV or –X ventrally (remainder of flagellum dark brown to black), maxillary and labial palpi, trochanters (basally dark brown to black), femora (dorsolateral portion of profemur and sometimes ventral portions of meso- and metafemora bright yellow; sometimes all femora dark brown ventrally and/or laterally), tibiae (protibia bright yellow dorsolaterally; sometimes dorsal portion of mesotibia and basidorsal

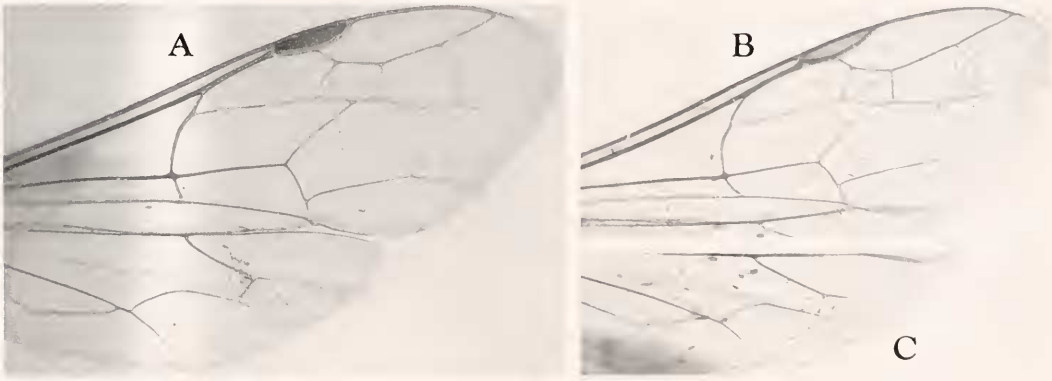

Fig. 5. Female wings (A, fore and hind wings; B, fore wing; C, hind wing). A, *I. hikosanus* n. sp., holotype; B–C, *I. punctipleuris* n. sp., paratype from the Philippines.


I. hikosanus H
I. nambui N
I. punctipleuris P

portion of metatibia dark brown to black), tarsi, and metasoma (tergum I dark brown to black anterodorsally and sublaterally; terga II–IV sometimes becoming darker dorsally). Posterolateral margin of mesoscutum, tegula, and wing bases yellowish brown. Mandible black; apical 1/3 dark rufous. Wings hyaline, iridescent in certain lights, weakly infuscate along outer margins. Pterostigma light to dark brown. *Punctation*: Upper frons (Figs 4C–D), vertex between eye and ocellus, pronotum, mesoscutum, discs of scutellum and metanotum, mesopleuron (Figs 4E–F), and lower metapleuron with irregularly-spaced, shallow punctures, these being larger and denser along median line of frons and scutal groove, and sometimes on mesopleuron. *Pubescence and setae*: Body and legs with short, appressed, white to pale brown pubescence but devoid of long bristly setae; vertex, mandible, propleuron, lateral side of pronotal disc, mesopleuron, metanotum, and posterolateral portion of propodeum with short, dense, white to pale brown setae. *Head*: 1.1–1.2 (1.2)× as broad as long. Vertex strongly convex in frontal view (Fig. 3B). Frons without interantennal tubercle (Fig. 3A); median line finely impressed from interantennal area close to anterior ocellus. Antennocular line slightly depressed nearby antennal base (Fig. 3C). Inner orbits distinctly emarginate at upper 1/3, strongly convergent below. UID: MID:LID=8.5–9.4:10:5.6–6.5 (9.3:10:5.9). MID 0.59–0.63 (0.61)× head width. Ocelli forming slightly acute triangle, this area being slightly raised. POL:OOL=1:1.6–2.5 (1.9). Clypeus feebly convex, 1.6–1.9 (1.8)× as broad as long; anterior margin truncate, weakly and arcuately emarginate (Fig. 3B); lateral sides strongly convergent towards apex. Labrum 2.0–2.3 (2.2)× as broad as long; anterior margin with small median notch. Malar space very short (Fig. 3A). Mandible sharply carinate laterally. Gena 0.4–0.5 (0.4)× eye width in profile, feebly rounded in dorsal view. Scape carinate on apical half ventrally; lateral face flattened but scarcely concave in dorsal view. Flagellomere I 2.1–2.4 (2.4)× as long as wide and 0.38–0.43 (0.38)× length of UID; flagellomeres I and II in ratio of 1:0.84–1.0 (0.94). *Mesosoma*: Pronotum short; anterior margin of disc almost straight in dorsal view, its lateral corner sub-angulate, but degree of angulation variable (Figs 3H–K); lower anterolateral tubercle not much swollen, being concealed by disc in dorsal view; posterior portion narrowly but distinctly depressed along posterior margin, the latter being arcuate. Mesoscutum with scutal groove shallowly impressed on anterior 1/4–3/4; parapsidal sulcus appearing as a fine, raised line; posterolateral margin narrowly reflexed. Discs of scutellum and metanotum strongly raised (Fig. 3D). Metapostnotum 0.59–1.0 (1.0)× length of metanotum at midline, deeply sunken between metanotum and propodeum, with fine, transverse striae anteriorly and short oblique striae posteriorly. Posteromedian lobes of mesosternum triangularly produced, their apices removed from each other (Fig. 3F). Upper metapleuron finely and obliquely striate. Propodeum short, barely convex in profile (Fig. 3D), deeply depressed along anterior margin, without lateral tubercle; infrastigmal tubercle weak; surface finely and transversely striate, with weak to rudimentary median groove. *Metasoma*: Much slenderer than mesosoma. Tergum I gradually narrowed and petiolate or parallel-sided basally (Fig. 3E). *Legs*: Longer spur of metatibia 0.63–0.72 (0.68)× length of metatarsomere I. Tarsal claws bifid; inner ray of claw truncate (Fig. 3G). *Wings*: Fore and

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Fig. 6. Map showing the known distribution of *Irenangelus hikosanus*, *I. nambui*, and *I. punctipleuris*. In Japan only certain localities of specimens, including type localities, have been selected for *I. hikosanus* and *I. nambui*.

hind wing venation as shown in Figs 5B and C, respectively. Fore wing crossvein 2r-rs originating slightly before middle of pterostigma. Crossvein cu-a usually originating at or slightly basad of point of separation of vein M+CuA. SMC2 almost rectangular, receiving crossvein 1m-cu at basal 0.43–0.57 (0.54). SMC3 narrowed on vein Rs by 0.75–0.85 (0.84)× its length on vein M, 1.3–1.8 (1.8)× as long as SMC2 on vein M, 1.2–1.8 (1.8)× as long as SMC2 on vein Rs, receiving crossvein 2m-cu at basal 0.39–0.61 (0.50). Hind wing crossvein rs-m almost vertical to vein M. Crossvein cu-a forming angle of approximately 150° to vein A.

Male.—Very similar to female. *Length*: Body 6.7–8.4 mm; fore wing 5.7–7.0 mm. *Head*: 1.2× as broad as long. UID:MID:LID=9.0:10:6.7–7.3. MID 0.62–0.65× head width. POL:OOL=1:1.9–2.1. Clypeus 2.0× as broad as long. Labrum 2.1–2.2× as broad as long. Gena 0.4–0.5× eye width in profile. Flagellomere I 2.3–2.4× as long as wide and 0.32–0.35× UID; flagellomeres I and II in ratio of 1:0.87–0.90. *Mesosoma*: Metapostnotum 0.75× length of metanotum at midline. *Legs*: Longer spur of metatibia 0.72× metatarsomere I. *Wings*: SMC2 receiving crossvein 1m-cu at basal 0.42–0.55. SMC3 narrowed on vein Rs by 0.77–0.78× its length on vein M, 1.4–1.7× as long as SMC2 on vein M, 1.3–1.5× as long as SMC2 on vein Rs, receiving crossvein 2m-cu at basal 0.45–0.67. *Subgenital plate* (Fig. 3M): Lateral sides gradually convergent towards apex; apical margin sub-triangularly produced; ventral surface with minute setae apically. *Genitalia* (Fig. 3L): Paramere with strong setae apicomedially; parapenial lobe long and slender, decurved apically, extending beyond apex of aedeagus.

Distribution.—From Japan through the Philippines and Malaysia to India and Sri Lanka (Fig. 6).

Type material.—Holotype ♀ (ZMUC), Philippines, Balabac Dalawan Bay, 7.x.1961, Noona Dan Exp. 61–62. Paratypes: **Philippines**: Tawi Tawi, Tarakawan, north of Batu Batu, 4.xi.1961 (1♀: ZMUC), 10.xi.1961 (1♀: FSAG), 12.xi.1961 (1♀: ZMUC), Noona Dan Exp. 61–62. **Brunei**: Ulu Temburong, Base camp hut, 300 m, 115 16'E 4 26'N, 16.ii–9.iii.1982, M. C. Day, 2♀ (BMNH, FSAG). **Sulawesi**: Central Sulawasi, Napu-valley, 100 km S/O, Palu, near Lore-Lindu National Park, 9.ii.2001, A. -M. Klein, 1♀ (FSAG). Utara, Dumoga-Bone Nat. Park, ii.1985, 1♀ (BMNH). **Bali**: W. Bali, near Negara, rainforest above Batuagung, 550 m, 4–6.xii.1911, C. v. Achterberg, 1♀ (RMNH). **Java**: W. Java, Djampang-Tengah, Mrs. Walsh, 1♀ (RMNH). **Borneo**: Sarawak, S.W. Gunung Buda, 64 km S. Limbang 4 13'N 114 56'E, 8–15.xi.1996, Malaise trap, S. L. Heydon & S. Fung, 1♀ (UCDC). **Malaysia**: S. E. Sabah, Danum Valley Field C., 117 48'E 4 58'N, x–xii.1986, P. Eggleton, 4♀ (BMNH), 1♀ (FSAG). S. E. Sabah, near Danum Valley Field, ca.150 m, 26.v–20.vi.1987 (4♀: RMNH; 3♀: FSAG), 20.vi–12.vii.1987 (1♀: RMNH), 13.ix–4.x.1987 (1♀: RMNH), Malaise trap, C. v. Achterberg & D. Kennedy. S. W. Sabah, near Long Pa Sia (West), 1020 m, 25.xi–9.xii.1987, Malaise trap, C. v. Achterberg, 1♀ (RMNH). S. W. Sabah, near Long Pa Sia (East), 1000 m, 1–13.iv.1987 (1♀), 25.xi–9.xii.1987 (1♀), Malaise trap, C. v. Achterberg, (RMNH). Pasoh Forest Reserve, Negeri S., 22.vii.1978 (1♀: AEIC), 7.ix.1978 (1♀: FSAG), 6.xi.1978 (1♀: AEIC), 8.i.1979 (1♀: AEIC), P. & M. Becker. Bukit Kutu, 30.i.1930, H. T. Padgen, 1♀ (BMNH). **India**: U. P. Garjia, 610 m, 26–29.iv.1969, Gupta, No. 335, 1♂ (FSAG). S. India, Madras ST., Anamalai Hills, 3500 f, v.1964, P. S. Nathan, 1♀ (CNC). Kerala, Periyar A. Sanctuary, 5–15.x.1979, 1♀ (BMNH). **Sri Lanka**: Kandy District, Udawattakele Sanctuary, 1800 f, 1–3.ix.1980, Malaise trap, K. V. Krombein et al., 1♀ (FSAG). **Japan**: Kawamata, Ôtaki-mura, Chichibu, Saitama Pref., 30.vi–1.vii.2004, A. Shimizu, 1♀ (TMUB). Marunomachi, Nirasaki-shi, Yamanashi Pref., 27.vi–5.vii.2005, Malaise trap, K. Hosoda, 1♂ (TMUB). Kanegasaki-chô, Tsuruga-shi, Fukui Pref., 3.vii.2001, H. Takahashi, 1♀ (TMUB).

Etymology.—The species name is derived from the punctate mesopleuron; puncti- (punctate) + pleuris (pleuron).

Remarks.—The present species is similar to "*Ceropales*" *tenuatus* Turner 1910 occurring in Australia in that 1) the flagellum is crenulate; 2) all tarsal claws are bifid; 3) the frons is devoid of an interantennal tubercle;

and 4) the metasomal tergum I is gradually narrowed and petiolate or parallel-sided basally. However, this new species is easily distinguished from the latter by the almost entirely rufous metasoma and the distinctly punctate mesopleuron.

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